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SALMON CANNERY WASTE FOR MINK FEED

FISHERY LEAFLET 405
FISH AND WILDLIFE SERVICE
United States Department of the Interior

United States Department of the Interior, Douglas McKay, Secretary
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Fishery Leaflet 405

Washington 25, D. C. November 1952

SALMON CANNERY WASTE FOR MINK FEED

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Contents

Page

Introduction..... 3
Methods and Equipment..... 4
Feeding Experiments..... 11
Breeding and Production Tests..... 11
Growth and Fur Development Tests..... 20
Conclusions..... 30
Literature Cited..... 31
List of Tables
Table 1 - Breeding, production, and food consumption data for mink feeding experiment 1..... 13
Table 2 - Breeding, production, and food consumption data for mink feeding experiment 2..... 15
Table 3 - Proximate composition and vitamin content of rations used in mink feeding experiment 3... 17
Table 4 - Breeding, production, and food consumption data for mink feeding experiment 3..... 18
Table 5 - Feed offered and consumed by mink on feeding experiment 4..... 21
Table 6 - Pelt classification of mink on feeding experiment 4..... 24
Table 7 - Proximate composition and vitamin content of pink salmon waste and of ration samples used in mink feeding experiment 5..... 25
Table 8 - Feed offered and consumed by mink on experiment 5..... 26
Table 9 - Kit mink losses in feeding experiment 5..... 28
Table 10 - Pelt classification of mink on feeding experiment 5..... 29

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List of Figures

Page

Figure 1 - Average weight of kit mink on feeding experiment 4..... 23
Figure 2 - Average weight of adult mink on feeding experiment 4..... 23
Figure 3 - Distribution of pelts by grades for feeding experiment 4..... 24
Figure 4 - Average weight of kit mink on feeding experiment 5..... 27
Figure 5 - Average weight of adult mink on feeding experiment 5..... 27
Figure 6 - Distribution of pelts by grades for feeding experiment 5..... 28

List of Illustrations

Illus. 1 - Experimental Fur Station, Petersburg, Alaska..... 3
Illus. 2 - Typical Southeastern Alaska commercial fur farm, Ketchikan vicinity..... 6
Illus. 3 - Interior of commercial fur farm. This view shows the long line of cages on one floor of the house. Every other cage has one board side in common. The water pan attached to the rear of each cage (lower right) is filled from the pipe just above it..... 6
Illus. 4 - Close up view of nest box. The metal strap (center) is the handle by which a sliding door, separating the nest box from the cage, is operated..... 7
Illus. 5 - Large power grinder..... 8
Illus. 6 - Large mechanical mixer used to mix ration ingredients to "hamburger-like consistency". 8
Illus. 7 - Feeding the mink. The feed is taken from pan and placed on cage. The wooden covers of the nest boxes (lower center) are down... 10
Illus. 8 - Placing feed on the wire top of each cage. The nest box covers have been removed (lower right)..... 10

Illustration Credits:

Cover by Gustav T. Sundstrom.

Illustration 1, prepared by Gustaf T. Sundstrom from a photograph by James R. Leekley.

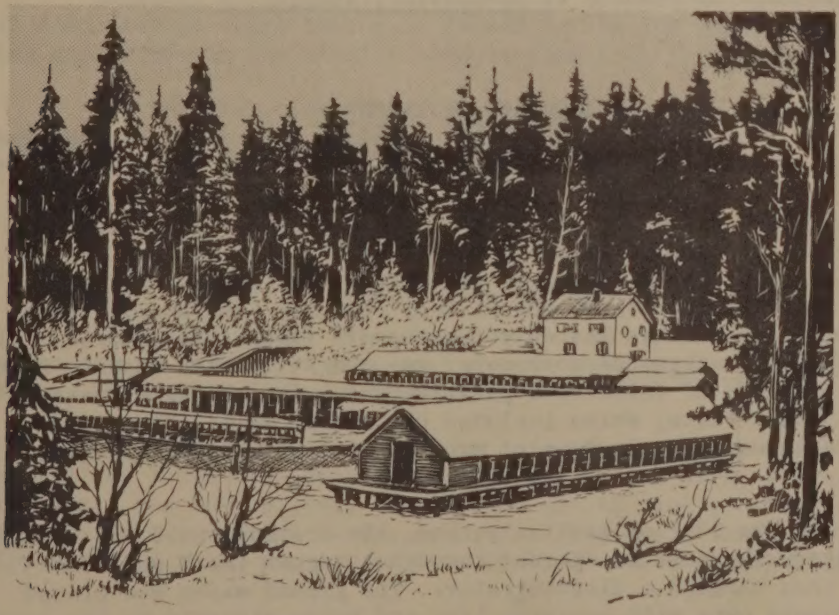
Photographs for illustrations 2 to 8 were taken by Norman B. Wigutoff at a commercial mink ranch in Ketchikan, Alaska.

INTRODUCTION

As fox farming in Alaska declined during the 1930's, the raising of mink in captivity attracted considerable interest. Unlike blue fox farming, where the animals ran at large on islands, mink ranching requires little land. The mink ranches, therefore, are generally located near the small towns where transportation, supplies, and commercial cold storage facilities are available. For years, whole salmon has been the most economical and easily obtainable mink food from the late fall months to the early spring and is still the preferred ration ingredient of most mink ranchers in Alaska for winter feed.

Since early in the 1940's salmon prices have been steadily rising. As a result salmon is no longer an economical mink feed. Regulations governing the taking of this fish have become more stringent with the result that now it is impractical to feed whole salmon to mink.

In a search for an economical feed ingredient, available in quantity to take the place of whole salmon, the Experimental Fur Station at Petersburg, Alaska, (illus. 1) instituted several feeding studies in 1945, 1946, and 1947. These studies utilized different percentages of salmon heads (obtained from Petersburg, Alaska, canneries) in the mink and fox diet. The results of these trials varied considerably and in general were inconclusive. They showed the necessity of further work.



Illus. 1 - Experimental Fur Station, Petersburg, Alaska.

The Fishery Products Laboratory at Ketchikan, Alaska, has made a number of studies designed to find practical uses for the waste from salmon canneries and hence cooperated with the Experimental Fur Station in this study of the use of salmon waste in the diet of mink.

Except for a small amount of salmon cannery waste that is processed to fish meal and oil, approximately 50,000 tons of salmon cannery waste are discarded annually in Alaska. Here is a potential source of raw material for use as fur farm feed, fish hatchery feed, meal, and other yet undeveloped byproducts.

Since the canning season is short and the waste is of a perishable nature, the utilization of salmon cannery waste poses somewhat of a problem. In this study, however, we were concerned with determining the suitability of salmon cannery waste either raw frozen or processed as the main component of mink rations.

Fur farmers in the States have shown interest in the possibility of using processed or raw frozen salmon waste as feed for fur animals. Salmon waste is being used at present to a limited extent in the Northwest, but the supply there is short. Hence, any large use of this waste would require the exploitation of the tremendous quantities available in Alaska.

In the experimental work reported here, members of the Fishery Products Laboratory collected the salmon waste, processed or froze it, and made the ration analyses. The mink-feeding experiments were carried out at the Experimental Fur Station at Petersburg, Alaska.

METHODS AND EQUIPMENT

Collection of Raw Material

The salmon cannery waste used in the following experiments was collected during the canning seasons of 1947, 1948, and 1949 and fed in experimental rations during each year immediately following. All waste was gathered by staff members of the Fishery Products Laboratory from a Ketchikan cannery, which handles only trap-caught fish. The material, all from pink salmon, Oncorhynchus gorbuscha, was caught in wire baskets that were lowered by means of rails to a position under the chutes from the "Iron Chink". This waste, which included the heads, tails, fins, and viscera, was allowed to drain free of excess water on a metal draining table.

During the 1947 collection period, the drained waste was brought to the Laboratory where it was passed through a hogger (meat and bone chopper) and then through a disintegrator. The ground waste was placed in 5-gallon square cans with press-on lids and taken directly to the local cold-storage plant for freezing and storage. Canned waste was prepared from this frozen material when needed.

The material gathered during the 1948 and 1949 seasons was handled as follows: The waste to be used raw was taken from the draining table as mentioned in the preceeding paragraph, and placed in 5-gallon cans. The whole waste was then taken directly to the cold-storage plant where it was frozen and stored.

The salmon waste to be processed was passed through a hogger, sealed in 4-pound flat cans, and processed for $3\frac{1}{2}$ hrs. at 12 lbs. steam pressure (117° C.).

This material, either raw frozen or processed, was delivered by boat to the Experimental Fur Station at Petersburg as required.

Fishery products other than the salmon waste were obtained in the following manner: Flounders, Pleuronectodae spp., usually available each year from mid-April until about the first of September, were purchased from local Petersburg fishermen who obtained them in conjunction with salmon and trout fishing operations. However, the greater portion of flounders used in the following experiments were obtained by trout fishermen using beach seines. These fish were partially dressed (stomachs and intestines were removed since the fish feed on mud bottoms and their stomachs often contain small clams and other foreign matter which may damage the grinder), block frozen in shallow pans (depth 5 in.), and stored in the fur station cold-storage room, where they were periodically reglazed.

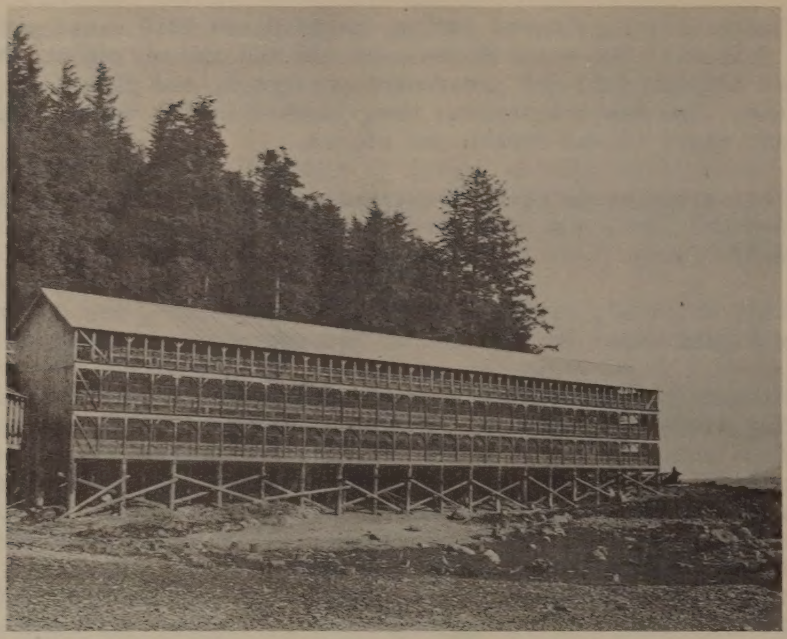
Halibut, Hippoglossus stenolepsis, heads were obtained from the local cold storage where they were frozen in shallow pans. They were glazed and stored in the station cold-storage room until used.

Red rockfish, Sebastodes ruberrimus (termed red snapper by local fishermen), and ling cod, Ophiodon elongatus, were bought from local fishermen, dressed, glazed, and stored in the station cold-storage room.

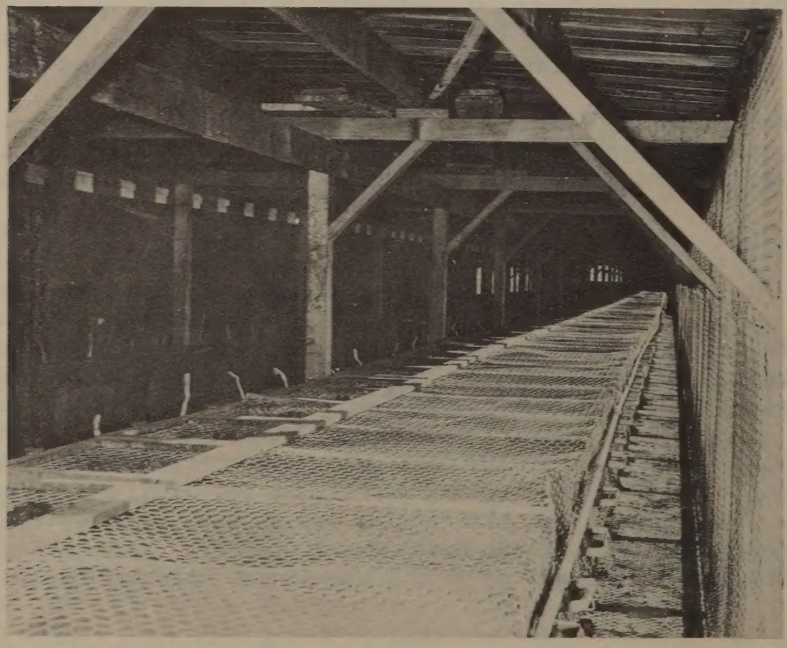
Animals and Housing

In general, mink available for use on experimental rations were of the standard dark type. Two or three mutation mink (platinum, pastel, or black cross) were included in each lot.

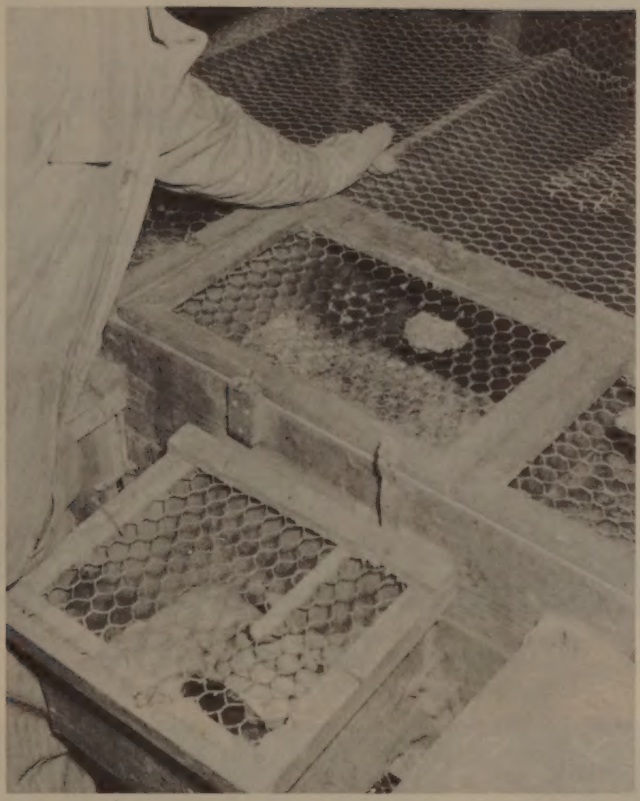
All animals were housed in a colony-type, fully covered mink house (illus. 2 and 3). Each animal pen was 14 in. high, 28 in. wide, and 5 ft. long. The bottom, top, and outside end of each pen were constructed of galvanized wire screen (1-in. mesh, No. 16 gauge). Each pen was equipped with a water pan and an 8 by 16 by 10 in. nest box (illus. 4).



Illus. 2 - Typical Southeastern Alaska commercial fur farm, Ketchikan vicinity.



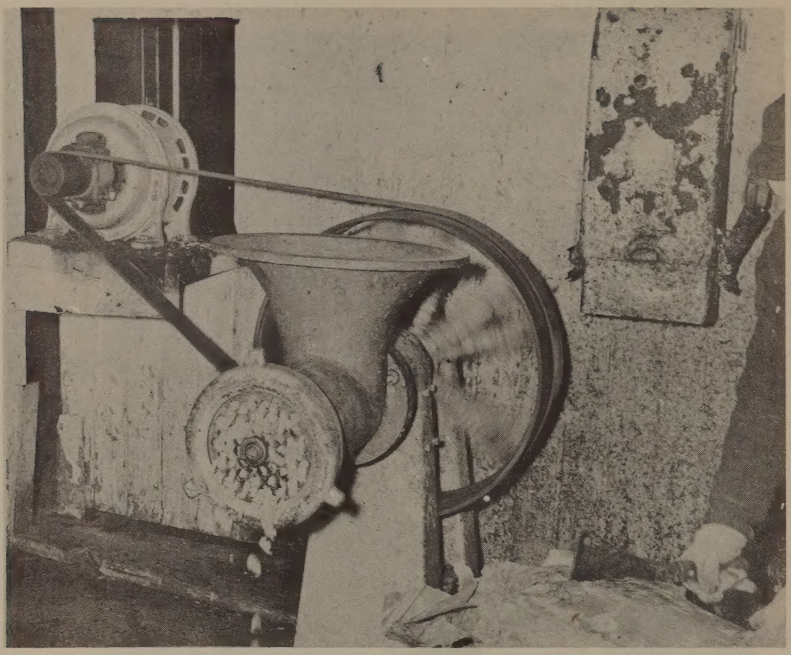
Illus. 3 - Interior of commercial fur farm. This view shows the long line of cages on one floor of the house. Every other cage has one board side in common. The water pan attached to the rear of each cage (lower right) is filled from the pipe just above it.



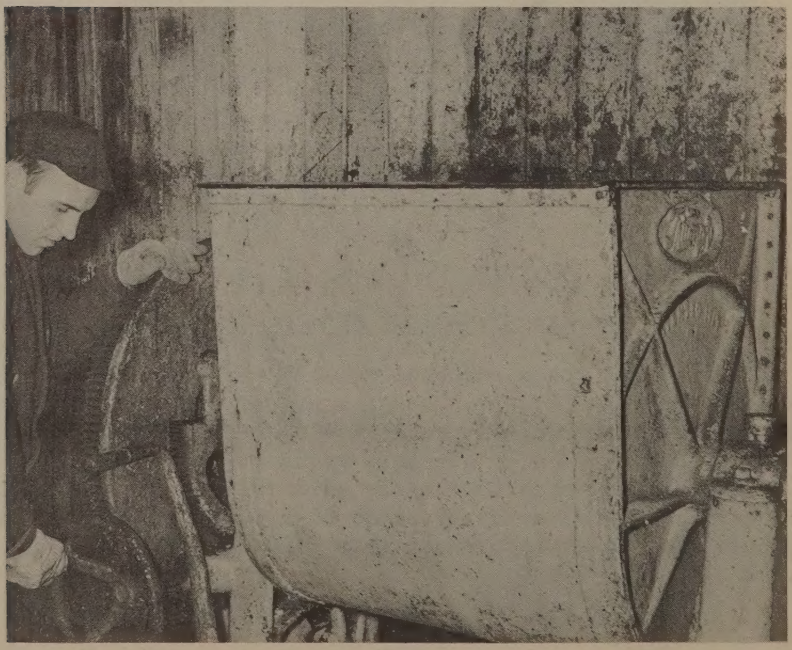
Illus. 4 - Close up view of nest box. The metal strap (center) is the handle by which a sliding door, separating the nest box from the cage, is operated.

Preparation of Rations and Feeding Methods

All frozen fishery products were thawed prior to grinding; they were removed from the cold storage a day or two before needed and allowed to thaw at room temperature on the feed-room floor. The thawed material was passed through an electric grinder (illus. 5) using the 5/16-in. hole plate and then thoroughly mixed with other ration ingredients to a hamburger-like consistency by means of a mechanical mixer (illus. 6). Representative samples were taken at this time for proximate and vitamin analyses.



Illus. 5 - Large power grinder.



Illus. 6 - Large mechanical mixer used to mix ration ingredients to "hamburger-like consistency".

The animals were watered both morning and evening and were fed once daily, between 3:00 and 4:30 p.m. Females with litters were fed both morning and afternoon. Feed was placed on the wire top of the nest box or pen (illus. 7 and 8) and was eaten through the 1-in. wire mesh. An attempt was made at all times to "full-feed" without undue waste. Feed not consumed was removed the following morning or in the case of lactating females fed in the morning, was removed by noon and weighed. Complete records were kept of the amount of feed offered, consumed, and rejected.

The quantity of fish or fishery material varied in different rations from 65 to 85 percent, depending upon other added components and the moisture content of the individual fishery product being studied. Other ration ingredients were varied in order to give a well-balanced diet.

Methods of Analysis

Proximate Composition. The proximate analysis procedures, as modified from those of the Association of Official Agricultural Chemists (1945), were as follows:

Ash: The sample was dried for 1 hr. at 130° C. ($\pm$ 5°). The preliminary ashing was done in a small muffle furnace at moderate temperatures (225° - 300° C.) until all smoking ceased. The final ashing was carried out in another muffle furnace at 525° C. for 3 hrs.

Moisture: The moisture content was determined by mixing the sample with sand and drying it at 70° C. for 1½ hrs. and then at 130° C. ($\pm$ 5°) for an additional hour.

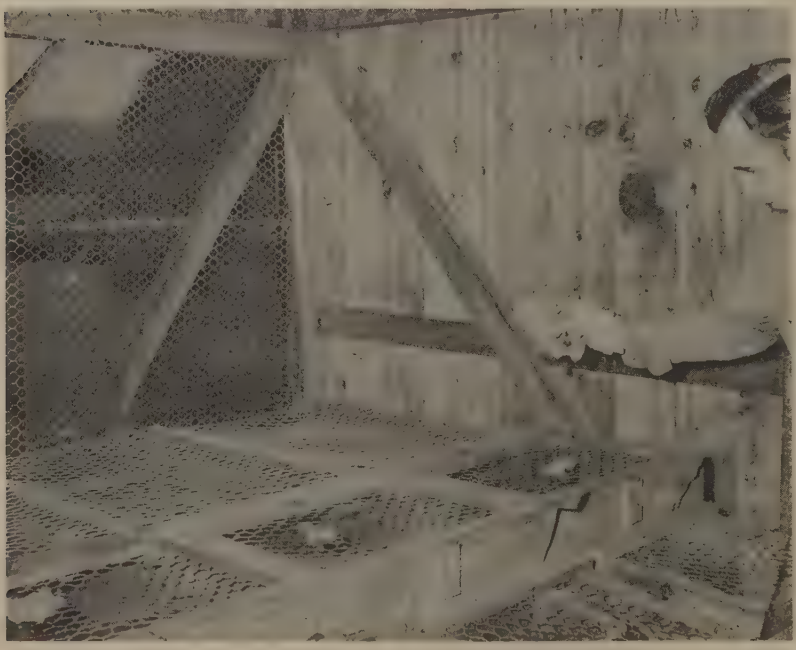
Protein: The protein content was estimated by multiplying the nitrogen content by 6.25. The nitrogen content was determined by the Kjeldahl method using selenized granules as the catalyst in the digestion of the sample.

Oil: The oil content was determined by extracting the sample for 16 hrs. with acetone, using a Bailey-Walker extractor. The acetone was evaporated over a water bath, and the material was dried for 3 hrs. at 100° C. in a vacuum oven. The oil was taken up in ether, and the weight of dry oil was determined according to the method of Stansby and Lemon (1937) as modified by Voth (1946).

Vitamin Content. The vitamin analyses were as follows:

Thiamin and Riboflavin: Except for slight modifications the fluorometric methods used were those given in the Association of Vitamin Chemists, "Methods of Vitamin Assay" (1947).

Illus. 7 - Feeding the mink. The feed is taken from pan and placed on cage. The wooden covers of the nest boxes (lower center) are down.



Illus. 8 - Placing feed on the wire top of each cage. The nest box covers have been removed (lower right).

Niacin and Biotin: These assays were modified from the microbiological method published by Roberts and Snell (1946). Lactobacillus arabinosus was used for the niacin assays and Lactobacillus casei for the biotin assays. The acid production for all assays was determined by titration. In the extraction of the samples for niacin, an enzymatic extraction (papain-takadiastase) was used. For biotin, the samples were autoclaved for 2 hrs. with 6 N HCl at 15 lbs. steam pressure.

Vitamin B_{12}: Vitamin B_{12} was also determined by the microbiological method. Basically a procedure modified from that published by Hoffman, Stokstad, Hutchins, Dornbush, and Jukes (1949) was used. This assay is still of doubtful accuracy. However, results can be considered reproducible to $\pm$ 15 percent.

Vitamin A: Difficulties were encountered in the spectrophotometric assay of the vitamin A content of the animal rations. Due to interference, probably caused by material added in the dry mix, the optical density did not reach a maximum at 328 mu but was greater at 300 mu. Therefore, no vitamin A data are reported here. However, all rations are believed to contain an adequate supply of vitamin A.

FEEDING EXPERIMENTS

Breeding and Production Tests

General Procedure

Three feeding trials (experiments 1, 2, and 3) which carried female mink through their breeding, gestation, and suckling periods on rations containing high percentages of whole pink salmon waste, processed pink salmon waste, and other fishery products were conducted in 1948, 1949, and 1950. Frozen pink salmon waste rations were fed in all experiments. Other rations, with various fishery materials as their main components, were introduced for comparison.

All of these trials were started approximately 6 weeks prior to the breeding season and terminated with the weaning of the last litter of kits at 50 days of age, unless undue losses occurred, justifying ending the experiment sooner. Nonbreeding females, females that mated but did not produce, and females that destroyed their litters were removed from the experiment as soon as their status was determined. For breeding purposes, males were carried to female pens and where possible, repeat matings on two consecutive days were attempted. All producing females and their kits (with exception of those females which destroyed their litters) were kept on experimental rations until the kits were 50 days of age, at which time the kits were weaned and all animals were removed from the experiment.

In order to have equalized groups, animals to be fed experimental rations were assigned to their respective groups, on the basis of past production, ancestry, average live weight at the start of the experiment, age, and previous rations received.

The kits were weighed on the 49th and 50th day after birth. The average of the weights taken on these two days constituted the weaning weight of the kits.

Experiment 1

Period Covered and Diets: Mink experiment 1 started January 28 and was terminated on July 12, 1948 (167 days). This trial compared four rations that were made up as follows: Group I, 70 percent frozen flounders and 10 percent horse meat; Group II, 80 percent frozen pink salmon heads; Group III, 80 percent frozen pink salmon waste; and Group IV, 80 percent canned (processed) salmon waste. In addition to the above components each ration contained 15 percent1/ dry mixture No. 1 2/, 2.5 percent brewer's inactive yeast, and 2.5 percent canned tomato puree. Eight adult and ten yearling females were allotted to each ration.

Breeding was started on March 10 and terminated on April 15, 1948. Breeding, production, and food consumption data are given in table 1.

Three adult females were lost from an undetermined cause prior to breeding. All of these were in Group I. In addition one female from Group IV died of nursing anemia a few days prior to the time her kits were to be weaned.

Eight kits (2 from Group II, 2 from Group III, and 4 from Group IV) were lost between 14 and 50 days of age. With the exception of the kit losses in Group IV, these losses were not deemed excessive. Three of the kits that died in Group IV were from a litter of seven, which had not made satisfactory gains in weight.

Generally speaking, the kits of Group I were in the best health as evidenced by their larger weaning weights and the fact that no losses occurred prior to the time they were separated from their mothers at 50 days of age.

1/ All percentages are on a wet basis.

2/ Ingredients in dry mixture No. 1: Ground whole wheat, 20%; Oatmeal, 20%; Alfalfa leafmeal, 10%; Skim milk powder, 10%; Soybean meal (expellor), 10%; Wheat germ meal, 10%; Brewer's yeast (inactive), 10%; Linseed oilmeal, 5%; Bone meal (steamed), 5%.

Table 1. - Breeding, Production, and Food Consumption Data for Mink Feeding Experiment 1

	Group I 70 percent frozen flounders and 10 percent horse meat1/	Group II 80 percent frozen pink salmon heads1/	Group III 80 percent frozen pink salmon waste1/	Group IV 80 percent canned pink salmon waste1/
Breeding and Production:				
Females started on experiment (number)	18	18	18	18
Females died prior to breeding (number)	3	0	0	0
Females mated (number)	11	16	11	15
Females producing (number)	9	11	9	11
Kits at 7 days of age (number)	38	43	42	46
Litters destroyed at birth (number)	1	0	0	1
Kits died prior to weaning (number)	0	2	2	4
Kits weaned per female started on experiment (average number)	2.1	2.2	2.2	2.3
Kits weaned per producing female (average number)	4.2	3.7	4.6	3.8
Average weight of kits when weaned at 50 days of age (pounds)	0.75	0.60	0.65	0.60
Average Food Consumption per Mink:				
Food offered (pounds)	85.5	66.0	73.7	62.8
Food consumed (pounds)	69.0	50.8	56.6	54.0
Food consumed (percent)2/	80.7	77.1	76.9	85.9
Days on experiment (number)3/	163	167	167	166

1/ See page 12 for complete rations. All percentages of feed ingredients are calculated on a wet basis.

2/ Percent Food Consumed is calculated by dividing total amount feed consumed by total amount feed offered and multiplying by 100.

3/ Number of days from start of experiment until weaning of the last litter of kits. Period of test varied with the weaning date of the last litter of kits in each Group.

Twenty-one kits were lost from Group II and 1 kit from Group IV between the 6th and 30th of July (7 days before end of test to 18 days after). The experiment ended July 12, 1948 (167 days). While these kits were placed on a different ration as they were weaned and taken off the experiment the above losses might be attributed to the experimental ration (salmon heads) they received. Most of these animals were lost because of "yellow fat" or steatitis (for information on "yellow fat" see Whitehair, Schaefer, and Elvehjem, 1949).

Experiment 2

Mink experiment 2 was started on February 1 and terminated with the weaning of the last litter on July 7, 1949 (157 days). The main protein portion of the rations was as follows: Group I, 70 percent frozen flounders; Group II, 80 percent frozen pink salmon waste; and Group III, 65 percent frozen red rockfish. Three groups, each including 9 adult and 14 yearling kit female mink, were fed on the above rations. In addition to the fish, each ration contained 14 percent dry mixture No. 2 3/, 2 percent wheat germ meal, and water to total 100 percent. Each of the three groups of females also received two teaspoons of wheat germ oil daily (during the first 83 days of the test) from February 1 through April 24.

Breeding was started on March 11 and terminated April 15, 1949. As before, repeat matings were attempted when possible. Complete breeding, production, and food consumption data are given in table 2.

One adult female in Group I was lost from an undetermined cause prior to breeding. In addition 4 females in Group II and 1 in Group III died of nursing anemia within 3 days prior to the time their kits were weaned.

The excessive kit loss in Group III was due primarily to cannibalism and an anemic condition not experienced before and can no doubt be ascribed to the ration fed (dressed red rockfish). The palatability of this ration is questionable since many animals went off feed. Although no vitamin analyses were made of the red rockfish, some of the essential vitamins were probably lost since the viscera were discarded when the fish were dressed.

3/ Ingredients in dry mixture No. 2: Cooked whole wheat (dextrinized), 30%; Cooked oat groats (dextrinized), 16%; Wheat germ meal, 10%; Dried brewer's yeast, 10%; Tomato pomace, 5%; Liver meal - commercial, 5%; Dried skim milk, 15%; Dehydrated grass or alfalfa leafmeal, having a carotene content of 65 mg. or more per lb., 5%; Ground limestone, 3%; Cod liver oil, containing at least 1800 I.U. of vitamin A and 175 units of vitamin D per gram, 0.5%; Salt, 0.5%.

Table 2. - Breeding, Production, and Food Consumption data for Mink Feeding Experiment 2

	Group I 70 percent frozen flounders1/	Group II 80 percent frozen pink salmon waste1/	Group III 65 percent frozen red rockfish1/
Breeding and Production:			
Females started on experiment (number)	23	23	23
Females died prior to breeding (number)	1	0	0
Females mated (number)	21	22	19
Females producing (number)	18	18	10
Kits at 7 days of age (number)	90	85	41
Litters destroyed at birth (number)	0	0	1
Kits died prior to weaning (number)	6	5	13
Kits weaned per female started on experiment (average number)	3.9	3.7	1.8
Kits weaned per producing female (average number)	5.0	4.7	4.1
Average weight of kits when weaned at 50 days of age (pounds)	0.70	0.60	0.65
Average Food Consumption per Mink:			
Food offered (pounds)	93.7	69.9	81.5
Food consumed (pounds)	77.7	51.0	63.9
Food consumed (percent)2/	82.9	72.9	78.3
Days on experiment3/	157	157	157

1/ See page 14 for complete rations. All percentages of feed ingredients are calculated on a wet basis.
2/ Percent Food Consumed calculated by dividing total amount feed consumed by total amount feed offered and multiplying by 100.
3/ Number of days from start of experiment until weaning of the last litter of kits. Period of test varied with the weaning date of the last litter of kits in each Group.

Experiment 3

Mink experiment 3 was started on February 2 and was terminated July 13, 1950 (162 days). Twelve adult and ten kit female mink were placed on each of four rations. The main protein portion of the rations was as follows: Group I, 84 percent canned pink salmon waste; Group II, 80 percent frozen pink salmon waste; Group III, 75 percent frozen whole pink salmon; Group IV, 70 percent frozen ling cod. Both of the salmon waste rations contained 14 percent dry mixture No. 3 4/; the whole salmon ration contained 10 percent; and the ling cod ration contained 12 percent. All rations contained 2 percent wheat germ meal. Two teaspoons of wheat germ oil were given to each group daily from February 21 until April 14, 1950. In order to prevent excessive losses from "yellow fat" the rations of Groups I, II, and III were changed on June 7 (125th day of the test) to the following: 70 percent flounders; 12 percent dry mixture No. 3; 2 percent wheat germ meal; and 16 percent water.

The above complete rations were analysed for ash, moisture, oil (fat), protein, and vitamins B_{12}, thiamin, riboflavin, niacin, and biotin. These data are given in table 3.

Breeding was started March 10 and terminated April 18, 1950. Complete breeding, production, and food consumption data are given in table 4.

Three adult females in Group IV died from nursing anemia shortly before their kits were 50 days of age.

Fifteen kits (3 in Group I, 2 in Group II, 8 in Group III, and 2 in Group IV) were lost prior to weaning. All of those lost in Group I were from a single litter. With the exception of Group III, these losses are not considered excessive. Six of those lost in Group III were from 2 large litters each of which contained 7 kits. All remaining kits made satisfactory gains in weight and were in good health when they were weaned at 50 days of age.

Kit losses which occurred after weaning but prior to August 1 (18 days after completion of test) might also be attributed to these rations. There were 7 deaths in Group II and 1 in Group III. Five of those occurring in Group II were from a single litter, although the kits of this litter had been separated and placed on a different ration (70 percent flounders) on June 7 (125th day of the test). These kits were all small and had not made satisfactory gains in weight by the time they were weaned.

4/ Ingredients in dry mixture No. 3: Cooked whole wheat (dextrinized), 30%; Cooked oat groats (dextrinized), 16%; Wheat germ meal, 10%; Dried brewer's yeast, 10%; Beet pulp, 5%; Liver meal - commercial, 5%; Dried skim milk, 15%; Dehydrated grass or alfalfa meal, having a carotene content of 65 mg. or more per lb., 5%; Ground limestone, 3%; Cod liver oil, containing at least 1800 I.U. of vitamin A and 175 units of vitamin D per gram, 0.5%; Salt, 0.5%.

Table 3. - Proximate Composition and Vitamin Content of the Rations Used in Mink Feeding Experiment 3

Ration Sample	Fishery1/ Component	Proximate Composition in Percent2/					Vitamin Content in Micrograms per Gram				
		Ash	Moisture	Oil	Protein	Carbohydrates3/	Niacin4/	Biotin4/	Thiamin	Riboflavin	B_{12}4/
Group I	84 percent canned pink salmon waste	3.78	63.8	8.0	16.5	7.9	22	0.14	1.4	3.7	0.04
Group II	80 percent frozen pink salmon waste	3.56	65.3	7.5	16.9	6.9	24	0.12	1.9	3.6	0.11
Group III	75 percent frozen whole pink salmon	2.41	71.3	3.1	17.7	5.5	22	0.08	2.2	3.9	0.08
Group IV	70 percent frozen ling cod	2.43	71.2	3.2	16.0	7.2	15	0.05	1.6	3.5	0.02

1/ See page 16 for complete ration ingredients.
2/ The results of all analyses are reported on a wet basis.
3/ By difference.
4/ These assays were carried out at the Service's Fishery Technological Laboratory in Seattle, Washington.

Table 4. - Breeding, Production, and Food Consumption Data for Mink Feeding Experiment 3

	Group I 84 percent canned pink salmon waste1/	Group II 80 percent frozen pink salmon waste1/	Group III 75 percent frozen whole pink salmon1/	Group IV 70 percent frozen ling cod1/
Breeding and Production:				
Females started on experiment (number)	22	22	22	22
Females died prior to breeding (number)	0	0	0	0
Females mated (number)	20	20	18	20
Females producing (number)	15	18	14	14
Kits at 7 days of age (number)	61	75	59	53
Litters destroyed at birth (number)	0	1	0	1
Kits died Prior to weaning (number)	3	2	8	2
Kits weaned per female started on experiment (average number)	2.6	3.3	2.3	2.3
Kits weaned per producing female (average number)	3.9	4.1	3.6	3.6
Average weight of kits when weaned at 50 days of age (pounds)	0.85	0.80	0.85	0.90
Average Food Consumption per Mink:				
Food offered (pounds)	74.4	74.2	90.4	82.1
Food consumed (pounds)	61.8	61.1	74.5	69.4
Food consumed (percent)2/	83.1	82.3	82.4	84.6
Days on experiment (number)3/	160	162	155	154

1/ See page 16 for complete rations fed and ration changes made because of high mortality. All percentages of feed ingredients are calculated on a wet basis.

2/ Percent Food Consumed calculated by dividing total amount feed consumed by total amount feed offered and multiplying by 100.

3/ Number of days from start of experiment until weaning of the last litter of kits. Period of test varied with the weaning date of the last litter of kits in each Group.

Summary

Poor breeding and over-all production were experienced in all four groups of experiment 1 (table 1). The average number of kits weaned per female started on the experiment was 2.2, which is considered extremely low. Normally, the average number of weaned kits per female should be close to 4.0. Thus, none of the four rations was satisfactory in this experiment.

Although, Groups II and IV, experiment 1, table 1 gave slightly better results from breeding (number of females mated) and production (actual number of kits produced) standpoints, the high loss of kits on the Group II ration (pink salmon heads) after the experiment had ended indicated that high percentages of salmon heads are detrimental to young mink from the time they eat solid food until they are approximately 10 weeks of age.

In contrast to the results obtained on experiment 1, Groups I and III (table 1), production in Groups I and II of experiment 2 (table 2) where somewhat similar rations were fed, was satisfactory. The Group III ration in experiment 2 was obviously inadequate from the standpoint of production. Furthermore, the kits of this Group had a high mortality. Although no vitamin analyses were made of the red rockfish, some of the essential vitamins were probably lost with the viscera when the fish were dressed. However, the kits that survived in Group III had weaning weights equal to those in the other two Groups.

The females lost due to nursing anemia had large litters. It is believed that their deaths may have been due partially to the ration fed, for if the aims of the experiment had permitted, special attention to their condition and needs may have prevented these losses. Interestingly, the kits of these females were all raised successfully.

Better breeding results were obtained in experiment 3 (table 4) than in experiment 1. However, the number of females in experiment 3 that mated but did not produce young was high. This is difficult to explain. The females fed the ration of 80 percent frozen pink salmon waste (Group II) gave the best production (table 4). Production results obtained with the Group III ration (75 percent frozen whole salmon) were contrary to those experienced in previous experiments at this station and at mink farms where a diet of whole pink salmon has proven to be satisfactory. Results of feeding ling cod (Group IV experiment 3, table 4) were similar to those obtained with red rockfish (Group III, experiment 2, table 2) in that in both groups the number of females which mated but did not produce young was high. Neither of these rations was satisfactory. The production obtained with the canned pink salmon waste ration in experiment 3 was somewhat better than that obtained in experiment 1 with the same ration although not entirely satisfactory. Kit losses experienced when the Group III ration (frozen whole salmon) was fed, were excessive, though of questionable significance since all but 2 of these kits were from 2 large litters. If these kits had been from smaller litters, they might have survived.

In work reported by Tove, Schaefer, and Elvehjem (1949) on the nutrition of mink a control ration was used which included the following amounts of vitamin supplements for each 100 grams of dry basal ration: 0.2 mg. thiamin HCl, 0.2 mg. pyridoxine HCl, 0.4 mg. riboflavin, 1.5 mg. calcium pantothenate, 4.0 mg. nicotinic acid, 0.5 mg. 2-methyl, 1-4 napthoquinone, and 0.025 mg. biotin. In addition, haliver oil fortified with gamma-tocopherol acetate and vitamin D_3 was added so that each 100 grams of their ration contained 4 mg. gamma-tocopherol, 1200 I.U. vitamin A, and 120 I.U. vitamin D_3. Table 3, which shows the results of vitamin assays of rations fed in feeding experiment 3, indicates that the vitamins in these rations are present in equal or greater quantities to the ration as used by Tove, et al (1949), when compared on the same (moisture-free) basis.

Frozen salmon waste was the most economical ration, for the only expenses involved were collection, freezing, and handling costs.

Growth and Fur Development Tests

General Procedure

Two experiments (Nos. 4 and 5) were carried out comparing salmon waste with other fishery materials as the main protein portion of rations fed to mink during their growing and furring out periods. Animals used on these experiments were the same type as those used in the breeding experiments. They differed, however, in that the majority of the animals used were young growing kits born during the preceding May. As in the breeding experiments these animals were divided into groups and equalized on the basis of age, average weight, sex, and ancestry. Each group of animals was housed under comparable conditions. Housing was the same as that described before with the exception that the kits were housed in the upper tier of pens above the adults in 14 by 14 in. by 5 ft. pens equipped with similar water pans, and nest boxes 8 by 8 by 10 in. Rations were prepared and fed once daily as described previously. Feed not consumed was redistributed the following morning and the excess picked up before noon and weighed.

An average of weights taken on the two consecutive days at the beginning and end of the experiment constituted the animals initial and final experimental weights, respectively. In addition these mink were all weighed at 28-day intervals throughout the experiment.

Experiment 4

Period Covered and Diets: Experiment 4 was started on August 12 and terminated on December 2, 1948 (112 days). The main protein portion of each ration fed to four groups of 22 adults and 32 kit mink was as follows: Group I, 65 percent red rockfish; Group II, 85 percent pink salmon waste; Group III, 75 percent canned pink salmon waste; and Group IV, 40 percent halibut heads plus 25 percent salmon heads. In addition, Group III contained 25 percent dry mixture No. 2. The other three groups received only 15 percent of this cereal mixture. Water made up the balance of the ration to 100 percent. Table 5 shows food consumption data for feeding experiment 4.

Table 5. - Feed Offered and Consumed by Mink on Feeding Experiment 4

Ration Sample	Fishery Component2/	Feed Offered per Mink	Feed Consumed per Mink	
		Pounds	Pounds	Percent1/
Group I	65 percent frozen red rockfish	58.9	54.3	92.3
Group II	85 percent frozen pink salmon waste	42.1	38.3	91.0
Group III	75 percent canned pink salmon waste	40.9	35.1	85.7
Group IV	40 percent halibut heads and 25 percent pink salmon heads	47.3	43.1	91.1

1/ $\frac{\text{Total lbs. of feed consumed}}{\text{Total lbs. of feed offered}}$ (100)

2/ See page 21 for complete ration ingredients. All feed percentage ingredients are expressed on the wet basis.

Note: Period of test was 112 days.

Weights taken at 28-day intervals throughout the experiment are shown graphically in figures 1 and 2. The animals were weighed in the morning to the nearest 0.05 lb. on a spring scale. The small gains made by the adults are normal because these were mature animals at the start of the experiment. The final average weight gains of the kits were as follows: Group I, 0.75 lbs.; Group II, 0.90 lbs.; Group III, 0.50 lbs.; Group IV, 0.80 lbs.

One adult and nine kit mink were lost on this experiment (2 kits in Group I; 1 kit in Group II; 1 adult and 1 kit in Group III; and 5 kits in Group IV). There was no one outstanding cause of death. One of the kits in Group I, and the adult and kit in Group III had stopped eating, lost weight, and become thin and emaciated prior to death. The other kit in Group I died of prolapse of the rectum. The kit death occurring in Group II and one in Group IV were caused by "yellow fat" disease. Of the other 4 deaths occurring in Group IV, 1 was diagnosed as pneumonia, as evidenced by the lung condition and a large amount of serous liquid in the thoracic cavity. Another death was caused by the kit being badly chewed on the back of the head. The cause of death of the other two kits was unknown.

In general the health of the animals on this experiment was good and the losses were not deemed excessive.

Fur experts separated the skins into three grades, on the basis of size, color, and quality of fur. The number of pelts in each grade is given in table 6. A number of the best animals from each lot were kept for breeding stock. This information is also given in table 6. These data are also presented graphically in figure 3. In the histogram the animals kept for breeders are counted as first-grade pelts.

Experiment 5

Mink experiment 5, which carried 4 groups of 21 adults and 42 kit mink through their growing and furring out period, was started July 8, and terminated November 25, 1949 (140 days). The main protein portion of the rations was as follows: Group I, 80 percent frozen pink salmon waste; Group II, 83 percent canned pink salmon waste; Group III, 40 percent frozen red rockfish and 25 percent frozen halibut heads; and Group IV, 40 percent frozen red rockfish and 25 percent frozen pink salmon heads. In addition, each ration contained 17 percent dry mixture No. 3. The balance of the ration to 100 percent was water. Excessive losses during July and August made several changes in the ration necessary. Frozen flounders were substituted for the salmon in Groups I and II for 5 days in July and in Group II for 21 days in August. The salmon heads in Group IV were replaced with frozen flounders from August 26 to the end of the experiment on November 25. The proximate composition and vitamin contents of the rations fed in this experiment are given in table 7.

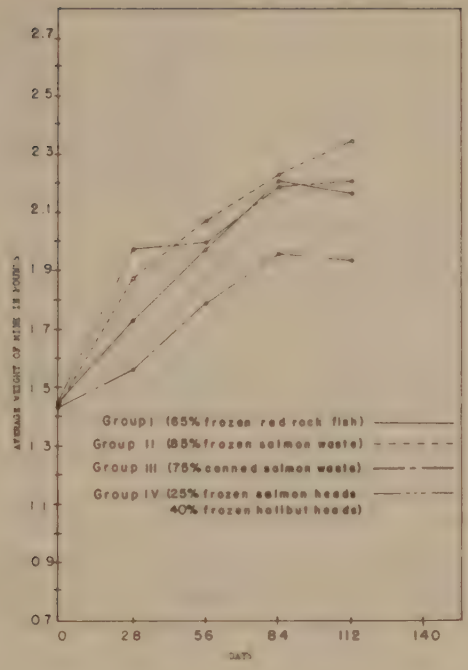


Figure 1 - Average weight of kit mink on feeding experiment 4.

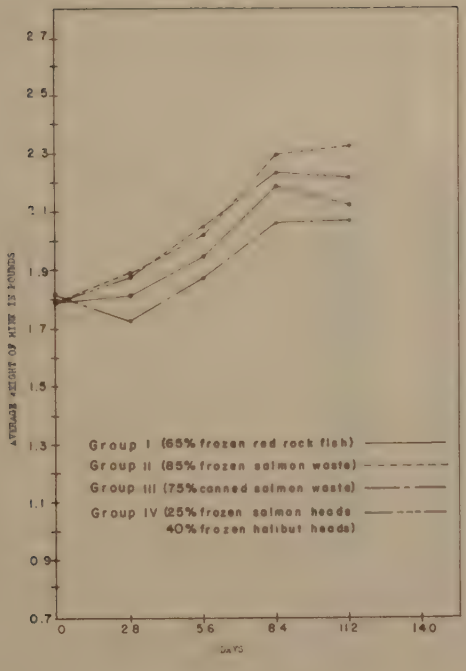
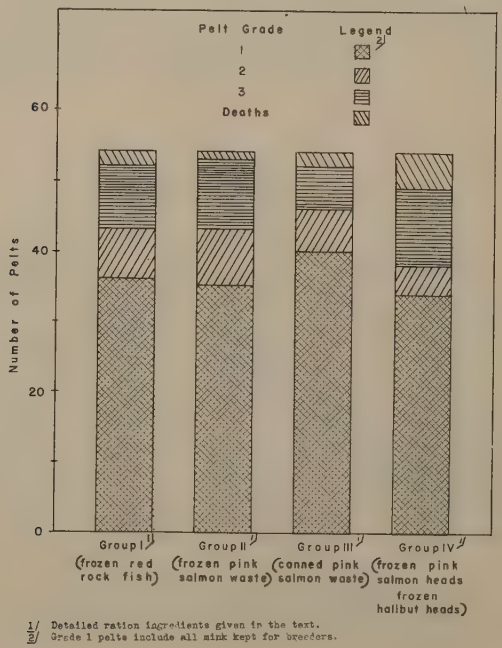


Figure 2 - Average weight of adult mink on feeding experiment 4.

Table 6. - Pelt Classification of Mink on Feeding Experiment 4

Grade of Pelt		Number of Pelts per Group			
		Group I 1/ 65 percent frozen red rockfish	Group II 1/ 85 percent frozen pink salmon waste	Group III 1/ 75 percent canned pink salmon waste	Group IV 1/ 40 percent frozen halibut heads
Classified Grade 1	Animals kept for breeders (Not pelted)2/	17	23	16	22
	Grade 1	19	12	24	12
	Total	36	35	40	34
Grade 2		7	8	6	4
Grade 3		9	10	6	11
Unclassified (Animal deaths)		2	1	2	5

1/ See page 21 for complete ration ingredients.
2/ Animals kept for breeders were classified as grade 1 pelts.



1/ Detailed ration ingredients given in the text.
2/ Grade 1 pelts include all mink kept for breeders.

Figure 3 - Distribution of pelts by grades for feeding experiment 4.

Table 7. - Proximate Composition and Vitamin Content of Salmon Waste and of Ration Samples Used in Mink Feeding Experiment 5

Sample	Ration Set Number[1]	Proximate Composition in Percent[2]					Vitamin Content in Micrograms per Gram				
		Ash	Moisture	Oil	Protein	Carbohydrates[3]	Niacin[4]	Biotin[4]	Thiamin	Riboflavin	B_{12}[4]
Frozen pink salmon waste	1	3.25	73.8	8.6	16.0	---	31	0.10	1.0	4.0	0.26
	2	2.66	73.4	8.1	16.0	---	20	0.14	0.7	3.0	0.13
Processed pink salmon waste	1	2.98	75.0	8.7	14.8	---	35	0.04	0.7	3.0	0.34
	2	---	---	---	---	---	---	---	---	---	---
Mink Ration Group I 5/ (80 percent frozen pink salmon waste)	1	4.52	62.2	8.9	17.2	7.2	42	0.06	1.9	4.7	0.18
	2	4.24	64.0	7.5	16.5	7.8	25	0.18	1.9	4.8	0.07
Mink Ration Group II 5/ (83 percent processed pink salmon waste)	1	3.76	63.0	7.5	16.2	9.5	44	0.06	2.9	4.4	0.20
	2	4.11	63.0	7.4	16.6	8.9	28	0.14	1.4	5.5	0.02
Mink Ration Group III 5/ (40 percent frozen red rockfish plus 25 percent frozen halibut heads)	1	4.15	67.2	5.6	14.4	8.6	31	0.04	3.2	4.3	0.02
	2	4.06	67.8	5.3	14.6	8.2	16	0.08	1.6	3.4	0.01
Mink Ration Group IV 5/ (40 percent frozen red rockfish and 25 percent flounders)	1	4.01	68.0	3.9	15.3	8.8	---	---	2.6	3.9	---
	2	4.20	69.5	3.5	14.7	8.1	15	0.09	1.9	4.5	0.02

1/ Two sets of samples were taken: set 1 at the beginning of the feeding experiment and set 2 at the end.
2/ Wet basis.
3/ By difference.
4/ These assays were carried out at the Service's Fishery Technological Laboratory in Seattle, Washington.
5/ For complete ration ingredients see page 22.
Note: --- indicates no data.

Table 8. - Feed Offered and Consumed by Mink on Experiment 5

Ration Sample	Fishery Component2/	Feed Offered per Mink	Feed Consumed per Mink	
		Pounds	Pounds	Percent1/
Group I	80 percent frozen pink salmon waste	58.3	54.9	94.2
Group II	83 percent canned pink salmon waste	57.9	54.1	93.5
Group III	40 percent frozen red rockfish and 25 percent frozen halibut heads	60.8	55.9	91.9
Group IV	40 percent frozen red rockfish and 25 percent frozen flounders	65.9	62.7	95.1

1/ $\frac{\text{Total lbs. of feed consumed}}{\text{Total lbs. of feed offered}}$ (100)

2/ See page 22 for complete ration ingredients. All feed percentage ingredients are expressed on the wet basis.

Note: Period of test was 140 days.

The animals on this experiment were weighed at 28-day intervals in a manner similar to that described previously and the data are shown graphically in figures 4 and 5. The final average weight gains of the kits were as follows: Group I, 1.85 lbs.; Group II, 1.60 lbs.; Group III, 1.40 lbs.; and Group IV, 1.50 lbs.

The large differences in gains between animals on experiments 4 and 5 are due for the most part, to the differences in age between the kits in the two experiments. The kits in experiment 4 were more than a month older when started on the experiment than those in experiment 5.

Although only one adult was lost in this experiment, the kit losses were heavy. The adult lost from Group III may have died from pneumonia. The various causes of kit death as diagnosed by gross examination are given in table 9.

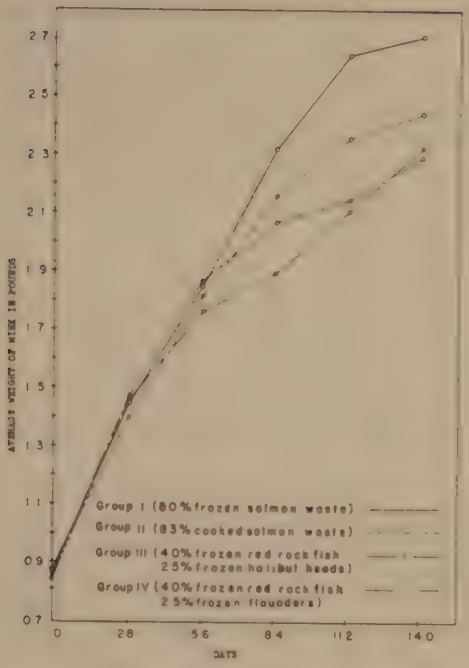

Group I (80% frozen salmon waste)
Group II (83% cooked salmon waste)
Group III (40% frozen red rock fish 25% frozen halibut heads)
Group IV (40% frozen red rock fish 25% frozen flounders)
DAYS

Figure 4 - Average weight of kit mink on feeding experiment 5.

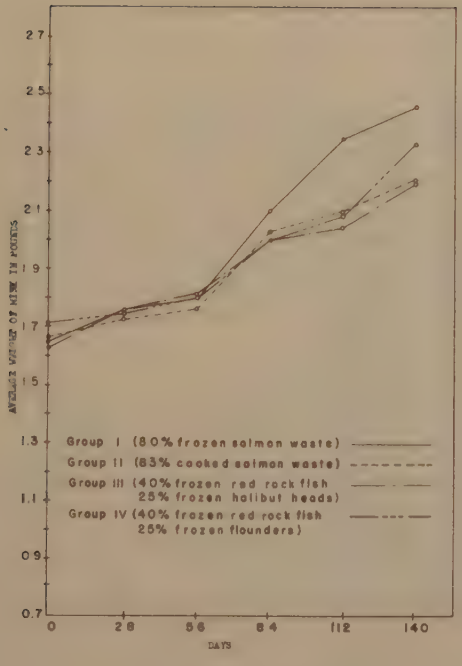

Group I (80% frozen salmon waste)
Group II (83% cooked salmon waste)
Group III (40% frozen red rock fish 25% frozen halibut heads)
Group IV (40% frozen red rock fish 25% frozen flounders)
DAYS

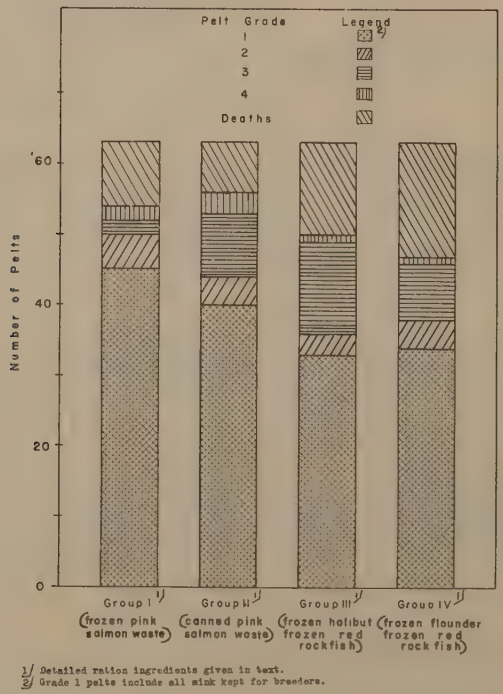
Figure 5 - Average weight of adult mink on feeding experiment 5.

Table 9. - Kit Mink Losses in Feeding Experiment 5

Group1/	Number of Mink	Number of Losses Due to			Total No. of Deaths
		"Yellow Fat"	Anemia	Undetermined	
I	42	5	1	3	9
II	42	5	1	1	7
III	42	1	5	6	12
IV	42	12	2	2	16

1/ See page 22 for details of ration group.

Pelts from animals in this experiment were classified into four different grades on the basis of size, color, and quality. The number of pelts in each grade is given in table 10. A number of the best animals from each lot were kept for breeding stock. This information is also given in Table 10. These data are presented graphically in figure 6. In the histogram the animals kept for breeders are counted as first-grade pelts.



1/ Detailed ration ingredients given in text.
2/ Grade 1 pelts include all mink kept for breeders.

Figure 6 - Distribution of pelts by grades for feeding experiment 5.

Table 10. - Pelt Classification of Mink of Feeding Experiment 5

Grade of Pelt		Number of Pelts per Group			
		Group I 1/ 80 percent frozen pink salmon waste	Group II 1/ 83 percent canned pink salmon waste	Group III 1/ 40 percent frozen red rockfish	Group IV 1/ 40 percent frozen red rockfish
Classified Grade 1 2/	Animals kept for breeders (Not pelted) 2/	22	19	13	16
	Grade 1	23	21	20	18
	Total	45	40	33	34
Grade 2		5	4	3	4
Grade 3		2	9	13	8
Grade 4		2	3	1	1
Unclassified (Animal deaths)		9	7	13	16

1/ See page 22 for complete ration ingredients.
2/ Animals kept for breeders were classified as grade 1 pelts.

Summary

Figures 1 and 2 show the relative weight gains between adults and kit mink and compare weight changes on the different rations of experiment 4. These figures show clearly that from the standpoint of weight gain, raw frozen pink salmon waste was the best ration fed and canned pink salmon waste the poorest. The amount consumed of the ration containing 75 percent canned pink salmon waste is significantly lower than the amount consumed of the other rations. However, the graph and table of pelt grades (figure 3, table 6) shows that the pelts from Group III (canned salmon waste) had the highest number of first-grade pelts.

In experiment 5, (table 8) the amount of food consumed by the mink on the Group I ration (80 percent pink salmon waste) and on the Group II ration (83 percent canned or processed salmon waste) was nearly equal and hence gives a good basis for comparing the effectiveness of the two rations. The results of experiment 5 (figures 4 and 5) show that the Group I (80 percent frozen pink salmon waste) ration was the best ration, from the standpoint of producing weight gains. This agrees with the results found in experiment 4. In experiment 5 the greatest number of first-grade pelts was also from those animals on the Group I (80 percent frozen pink salmon waste) ration (table 10, figure 6).

When both breeding and pelting periods are considered, the results of the two experiments indicate that frozen salmon cannery waste is the best of the fish products tested.

CONCLUSIONS

1. Frozen pink salmon cannery waste shows considerable promise as the main protein portion of the ranch mink diet.

2. Both adult and kit mink (3 months or older) made better weight gains when fed raw frozen salmon waste than when fed any of the other fish products tested (processed pink salmon waste, frozen flounders, frozen pink salmon heads, frozen red rockfish, frozen whole pink salmon, frozen ling cod, and frozen halibut heads).

3. Frozen raw pink salmon waste is a more satisfactory protein ingredient than the processed waste when used for feeding female mink during the breeding and gestation period up to the weaning of the young.

4. Subject to further tests, the authors are unable to recommend feeding pink salmon waste to young mink approximately 1 to 3 months of age.

ACKNOWLEDGMENT

Acknowledgment is made to Neva L. Karrick, Chemist, Fishery Technological Laboratory, Branch of Commercial Fisheries, Seattle, Washington, for carrying out the assays of vitamin B_{12}, niacin, and biotin in certain rations.

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